HOT ELECTRON TRANSISTOR AND SEMICONDUCTOR DEVICE INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The priority application numbers JP2007-21730, Hot Electron Transistor and Semiconductor Device including the Same and Method of Fabricating Hot Electron Transistor, Jan. 31, 2007, Yoichi Takeda, Hideaki Fujiwara, Shinya Naito, JP2007-341214, Hot Electron Transistor and Semiconductor Device including the Same, Dec. 28, 2007, Yoichi Takeda, Hideaki Fujiwara, Shinya Naito, upon which this patent application is based are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a hot electron transistor and a semiconductor device including the same, and more particularly, it relates to a hot electron transistor formed with a collector barrier layer and an emitter barrier layer and a semiconductor device including the same.

[0004] 2. Description of the Background Art

[0005] A hot electron transistor formed with a collector barrier layer and an emitter barrier layer is known in general.

[0006] As a conventional hot electron transistor, a hot electron transistor comprising a collector layer, a base layer, an emitter layer, a collector barrier layer formed between the collector layer and the base layer, an emitter barrier layer formed between the base layer and the emitter layer is disclosed. This hot electron transistor is configured such that the collector barrier layer is formed by i-type germanium-silicon and the emitter barrier layer is formed by i-type aluminum gallium arsenide (low-concentration n-type gallium arsenide), in order that the height of a barrier of the collector barrier layer may be rendered lower than that of a barrier of the emitter barrier layer. In the hot electron transistor, when a prescribed bias is applied, electrons pass through the emitter barrier layer from the emitter layer due to tunneling or pass over the emitter barrier layer to reach the base layer and become hot electrons having high energy. These hot electrons pass through at a high speed without hardly scattered in the base layer (ballistic conduction) and reach the collector layer through the collector barrier layer.

[0007] In the conventional hot electron transistor, however, when electrons moves from the emitter layer to the base layer due to the tunneling, the electrons pass through the energy barrier of the emitter barrier layer and hence a large amount of current is disadvantageously difficult to flow. Thus, it is disadvantageously difficult to obtain desired high-frequency characteristic and a driving current required for a subsequent circuit.

SUMMARY OF THE INVENTION

[0008] A hot electron transistor according to a first aspect of the present invention comprises a collector layer, a base layer, an emitter layer, a collector barrier layer formed between the collector layer and the base layer, and an emitter barrier layer formed between the base layer and the emitter layer, wherein an energy barrier between the emitter barrier layer and the emitter layer does not substantially exist and the height of an energy barrier of the collector barrier layer is lower than the height of an energy barrier of the emitter barrier layer.

[0009] A semiconductor device according to a second aspect of the present invention comprises a substrate, a transistor formed on the substrate, an interlayer dielectric film so formed on a surface of the substrate as to cover the transistor, and a hot electron transistor formed on a surface of the interlayer dielectric film, wherein the hot electron transistor includes a collector layer, a base layer, an emitter layer, a collector barrier layer formed between the collector layer and the base layer and an emitter barrier layer formed between the base layer and the emitter layer, and an energy barrier between the emitter barrier layer and the emitter layer does not substantially exist and the height of an energy barrier on an interface between the base layer and the collector barrier layer viewed from Fermi energy of the base layer is smaller than the height of an energy barrier on an interface between the base layer and the emitter barrier layer.

[0010] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is a sectional view showing a structure of a hot electron transistor according to a first embodiment of the present invention;

[0012] FIGS. **2** and **3** are diagrams showing an energy band of a conductive band of the hot electron transistor according to the first embodiment;

[0013] FIGS. **4** to **9** are sectional views for illustrating a process for fabricating the hot electron transistor according to the first embodiment;

[0014] FIG. **10** is a sectional view showing a structure of a semiconductor device according to a second embodiment;

[0015] FIG. **11** is a sectional view showing a structure of a hot electron transistor according to a third embodiment; and

[0016] FIGS. **12** to **17** are sectional views for illustrating a process for fabricating the hot electron transistor according to the third embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Embodiments of the present invention will be hereinafter described with reference to drawings.

First Embodiment

[0018] A structure of a hot electron transistor **100** according to a first embodiment of the present invention will be now described with reference to FIGS. **1** to **3**.

[0019] In the hot electron transistor **100**, a subcollector layer **2** made of T**1** is formed on a prescribed region of a surface of a silicon substrate **1** as shown in FIG. **1**. This subcollector layer **2** has a thickness of about 5 nm and is formed as an underlayer for forming an after-mentioned collector layer **3**.

[0020] The collector layer **3** made of TiN is formed on a surface of the subcollector layer **2**. This collector layer **3** has a thickness of about 100 nm. The collector layer **3** made of TiN has a prescribed nitrogen atom (N) concentration and a work function of about 4.7 eV.